

**NISTIR 6191**

---

# Demonstration Of Biodegradable, Environmentally Safe, Non-Toxic Fire Suppression Liquids

---

**Daniel Madrzykowski  
David W. Stroup, Editors**

**July 1998**



**U.S. Department of Commerce  
Technology Administration  
National Institute of Standards and Technology  
Gaithersburg, MD 20899**



*Prepared for:*  
**Federal Emergency Management Agency  
U.S. Fire Administration  
Emmitsburg, MD 21727-8998**

**NISTIR 6191**

---

# Demonstration Of Biodegradable, Environmentally Safe, Non-Toxic Fire Suppression Liquids

---

**Daniel Madrzykowski**  
**David W. Stroup, Editors**

July 1998



**U.S. Department of Commerce**  
**William M. Daley, Secretary**  
**Technology Administration**  
**Gary R. Bachula, Under Secretary for Technology**  
**National Institute of Standards and Technology**  
**Raymond G. Kammer, Director**



*Prepared for:*  
**Federal Emergency Management Agency**  
**James Lee Witt, Director**  
**U.S. Fire Administration**  
**Carrye B. Brown, Administrator**



**APPENDIX E**

**UNDERWRITERS LABORATORIES REPORT**

**CLASS D TESTS**



Underwriters Laboratories Inc. ®

333 Plingsten Road  
Northbrook, Illinois 60062-20  
(708) 272-8800  
FAX No. (708) 272-8129  
MCI Mail No. 254-3343  
Telex No. 6502543343



REPORT OF  
MAGNESIUM CHIP FIRE TESTS  
UTILIZING BIODEGRADABLE, ENVIRONMENTALLY SAFE,  
NONTOXIC, LIQUID FIRE SUPPRESSION AGENTS

PREPARED BY  
UNDERWRITERS LABORATORIES INC.  
PROJECT 95NK22435/NC3067

FOR THE  
NATIONAL INSTITUTE OF  
STANDARDS & TECHNOLOGY

Gaithersburg, MD  
OCTOBER, 1995

Copyright © 1995 Underwriters Laboratories Inc.

Underwriters Laboratories Inc. authorizes the above  
named organization to reproduce this Report provided it  
is reproduced in its entirety.

A not-for-profit organization  
dedicated to public safety  
committed to quality service

# N O T I C E

This Report was prepared as an account of work sponsored by the National Institute of Standards and Technology (NIST). Neither NIST nor Underwriters Laboratories Inc. nor any of their employees nor their contractors, sub-contractors, or their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for damages arising out of or in connection with the interpretation, application or use of or inability to use any information, apparatus, product or processes disclosed, or represents that its use would not infringe on privately owned rights. This Report may not be used in any way to infer or to indicate acceptability or unacceptability for Listing, Classification, Recognition or Certificate Service by Underwriters Laboratories Inc. of any product or system.

## EXECUTIVE SUMMARY

Under this project, magnesium chip fire tests as outlined in the Standard for Safety for Rating and Fire Testing of Fire Extinguishers, ANSI/UL 711, were conducted to evaluate the fire fighting effectiveness on this combustible metal using liquid fire suppression agents, identified by NIST as biodegradable, environmentally safe, and nontoxic, when applied using hand hoselines. For comparison purposes, fire tests were also conducted using water only and a UL Listed Class D dry powder agent. Only the UL Listed Class D dry powder agent demonstrated compliance with the fire extinguisher criteria outlined in ANSI/UL 711.

# TABLE OF CONTENTS

	<u>Page No.</u>
EXECUTIVE SUMMARY	i
TABLE OF CONTENTS	ii
LIST OF TABLES	iii
LIST OF FIGURES	iv
LIST OF ILLUSTRATIONS	v
ACKNOWLEDGEMENTS	vi
 1.0 INTRODUCTION	
Objective	1
Test Plan	1
 2.0 SAMPLES AND FACILITIES	
Agents	
Discharge Devices	2
Fire Test Building	2
 3.0 PERFORMANCE TESTS	
Magnesium Chip Fire Tests	5
 4.0 DISCUSSION AND RECOMMENDATIONS	
Discussion	14
Recommendations	14

**LIST OF TABLES**

<u>Table No.</u>	<u>Description</u>	<u>Page No.</u>
I	Magnesium Chip Fire Test Results	6



**LIST OF FIGURES**

<u>Figure No.</u>	<u>Description</u>	<u>Page No.</u>
1	Magnesium Chip Fire Test - Class D Dry Powder	7
2	Magnesium Chip Fire Test - Water Only	8
3	Magnesium Chip Fire Test - Liquid Agent A - 1%	9
4	Magnesium Chip Fire Test - Liquid Agent B - 1%	10
5	Magnesium Chip Fire Test - Liquid Agent C - 6%	11
6	Magnesium Chip Fire Test - Liquid Agent D - 3%	12
7	Special Magnesium Chip Fire Test - Water Only - Spray And Stream	13

**LIST OF ILLUSTRATIONS**


<u>ILL. No.</u>	<u>Description</u>	<u>Page No.</u>
1	General Fire Test Arrangement - Plan View	3
2	General Fire Test Arrangement - Elevation View	4

## A C K N O W L E D G E M E N T S

UL wishes to thank Mr. Dan Madrzykowski of the National Institute of Standards and Technology for his support during the conduct of these fire tests.

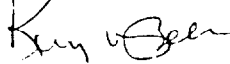
Respectfully Submitted:

  
MARTIN J. PABICH  
Project Engineer  
Engineering Services, Dept 411

  
WILLIAM M. CAREY  
Senior Staff Engineer  
Engineering Services, Dept 411

MJP/KMB/WMC/WSM:kb  
NC3067.Oct

Reviewed by:

  
KERRY M. BELL  
Associate Managing Engineer  
Engineering Services, Dept 411

  
WILLIAM S. METES  
Managing Engineer  
Engineering Services, Dept 411

## **1.0 INTRODUCTION**

### **OBJECTIVE:**

The objective of this investigation was to develop test data and investigate test methods as related to the fire fighting effectiveness of water only and biodegradable, environmentally safe, nontoxic, liquid fire suppression agents discharged from hand hoselines as compared to a UL Listed Class D dry powder agent when used on fires involving magnesium chips a Class D combustible metal.

### **TEST PLAN:**

A series of magnesium chip fire tests, as described in ANSI/UL 711, were planned to be conducted under this project.

## **2.0 SAMPLES AND FACILITIES**

### **AGENTS:**

Four biodegradable, environmentally safe, nontoxic, liquid fire suppression agents, water, and a UL Listed Class D dry powder agent were used in this investigation.

### **DISCHARGE DEVICES:**

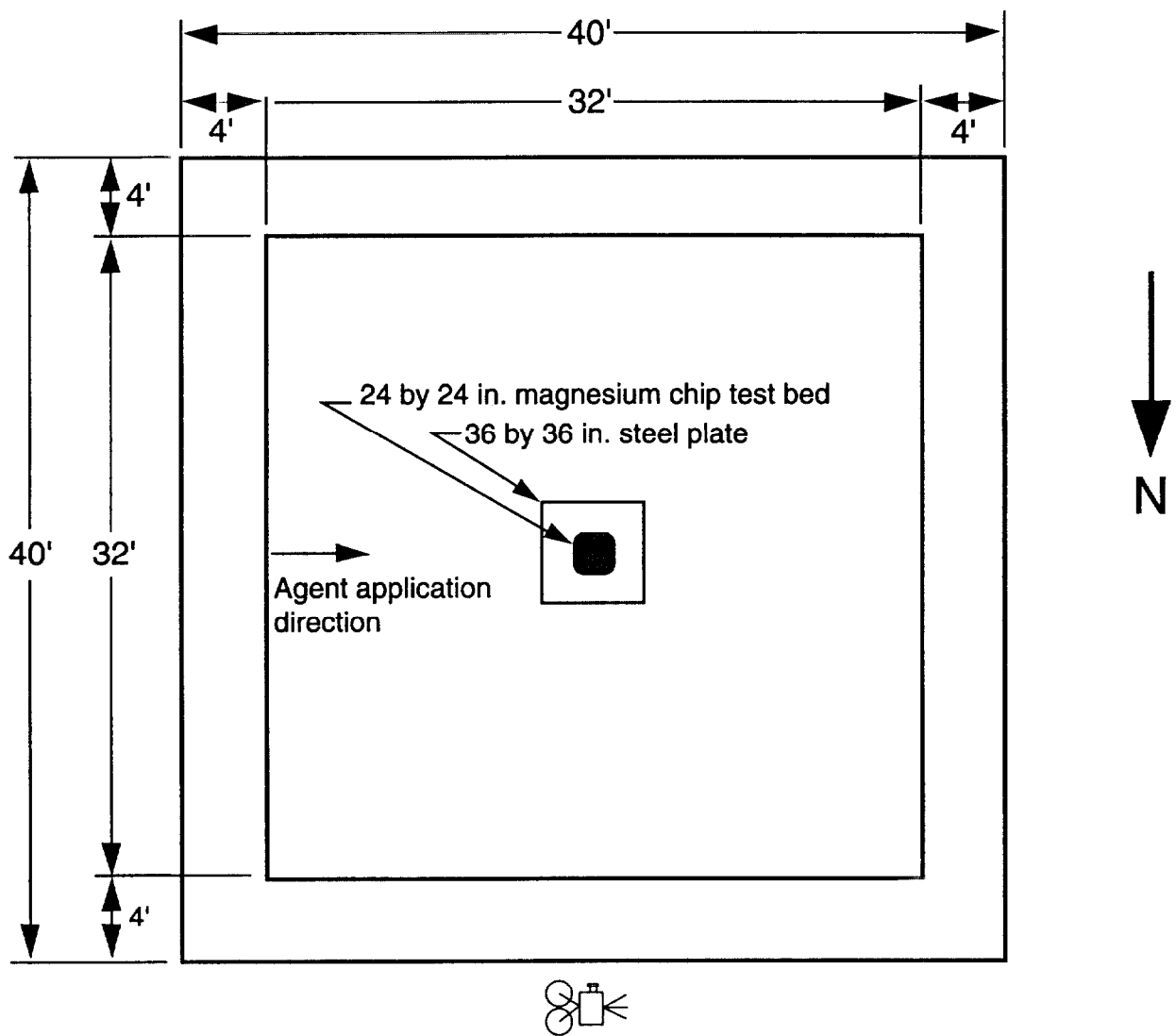
Hand held discharge devices were used to apply the liquid agents, water or Class D dry powder for the fire tests.

For the fire tests involving the liquid agents or water, a single adjustable pattern discharge nozzle was used to discharge the liquid agents or water at a flow rate of 10 gpm. The nozzle was adjusted to a straight stream pattern and fitted with an air aspirating attachment for one series of fire tests and used as a spray nozzle without the air aspirating attachment for a second series of tests.

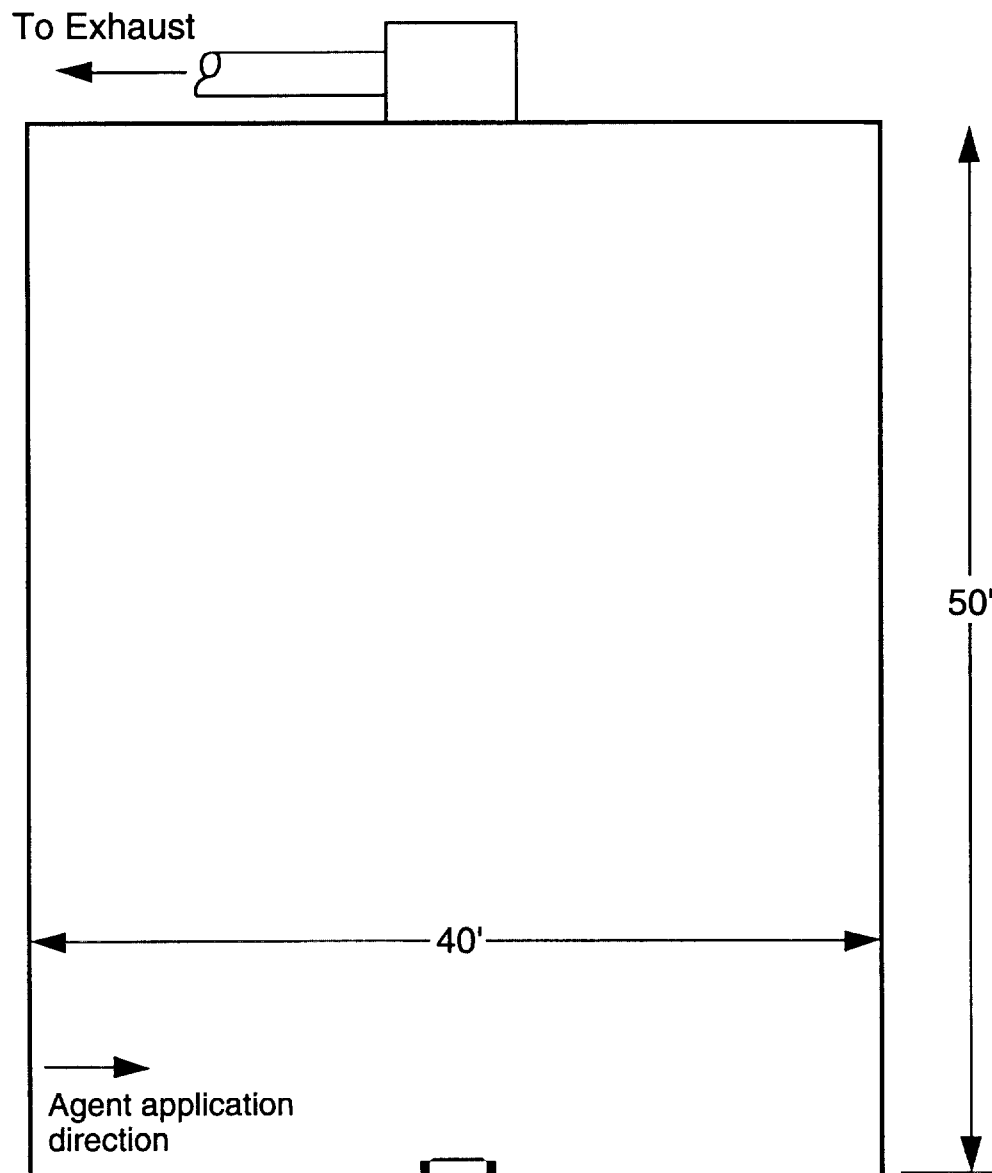
For the fire tests involving the Class D dry powder, a nominal 30 lb dry powder extinguisher was used to apply the agent onto the fire.

### **FIRE TEST BUILDING:**

The fire tests were conducted at UL's test facilities located in Northbrook, IL. The test building measured 40 by 40 by 50 ft in height and was equipped with a 30,000 cfm regenerative incinerator for smoke abatement purposes. The unit was operated at a rate of approximately 10,000 cfm for these tests. See ILLS. 1 and 2.



General Fire Test Arrangement  
Plan View



UL'S Highrise Test Building  
40' x 40' x 50' High  
General Fire Test Arrangement  
Elevation View

### **3.0 PERFORMANCE TESTS**

#### **MAGNESIUM CHIP FIRE TESTS:**

##### **METHOD**

The magnesium chip fire tests involved the use of 20 or 40 lbs of dry grignard magnesium grade chips arranged in a 2 by 2 ft area on a 1/4 in. thick steel plate. The grignard chips were approximately 1/4 to 3/8 in. long, 1/8 in. wide and 1/10 in. thick.

The grignard chips were ignited using a hand torch. For Fire Test Nos. 1-12, the bed of chips was ignited along one side and allowed to burn undisturbed until a deep seated condition was observed such that approximately 50 percent of the magnesium was consumed. For Fire Test No. 13, the magnesium was ignited on all four sides.

Following the freeburn period, the magnesium chip fire was attacked with the fire suppression agent. For Fire Test Nos. 1 and 2, the fire was attacked using a fire extinguisher containing a UL Listed Class D dry powder agent from a distance of approximately 5 ft. For Fire Test Nos. 3-13, the fire was attacked using a hand held nozzle discharging water or agent at a rate of 10 gpm from a distance of approximately 15 ft and for a duration of 5 min.

During each fire test, observations were made for the following:

- Fire extinguishment.
- Reaction of applied agent with the magnesium.
- Approximate amount of magnesium consumed.
- Fire spread.

##### **RESULTS**

The results of the magnesium chip fire tests are presented in Table 2 and Figs. 1-7. The fire tests utilizing the Class D dry powder extinguishing agent were rapidly extinguished with no visual adverse reaction. Fire extinguishment was not achieved in any of the fire tests involving the use of water or liquid fire suppression agents.



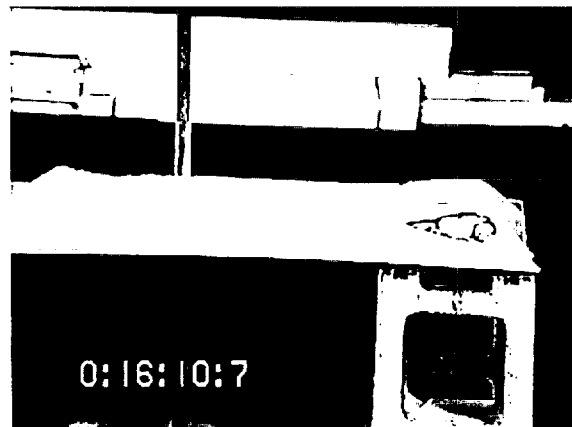
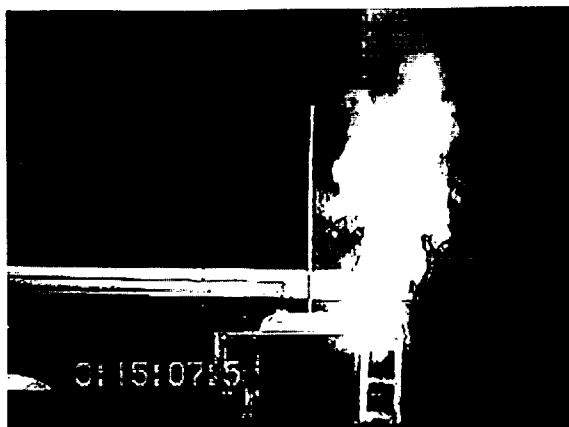
TABLE I - MAGNESIUM CHIP FIRE TEST RESULTS

<u>Test No.</u>	<u>Pounds Of Magnesium</u>	<u>Extinguishing Agent Type</u>	<u>Approx. Preburn min:sec</u>	<u>Extinguishing Agent Application</u>			<u>Visual Adverse Reaction</u>	<u>Increased Intensity of Fire</u>	<u>Fire Spread Beyond Steel Plate</u>	<u>Fire Extinguished</u>	<u>Comments</u>
				<u>Method</u>	<u>Rate (gpm)</u>	<u>Duration (min:s)</u>					
1	20	Class D Powder	15:00	Direct	NA	0:32	None	No	No	Yes	1
2	40	Class D Powder	25:00	Direct	NA	0:34	None	No	No	Yes	1
3	20	Water	25:00	Stream	10	5:00	Sparking	Substantial	Yes	No	2
4	20	Water	25:00	Spray	10	5:00	Sparking	Moderate	Yes	No	3
5	20	Liquid-A 1%	25:00	Stream	10	5:00	Sparking	Substantial	Yes	No	2
6	20	Liquid-A 1%	25:00	Spray	10	5:00	Sparking	Moderate	Yes	No	3
7	20	Liquid-B 1%	25:00	Stream	10	5:00	Sparking	Substantial	Yes	No	2
8	20	Liquid-B 1%	25:00	Spray	10	5:00	Sparking	Moderate	Yes	No	3
9	20	Liquid-C 6%	25:00	Stream	10	5:00	Sparking	Substantial	Yes	No	2
10	20	Liquid-C 6%	25:00	Spray	10	5:00	Sparking	Moderate	Yes	No	3
11	20	Liquid-D 3%	25:00	Stream	10	5:00	Sparking	Substantial	Yes	No	2
12	20	Liquid-D 3%	25:00	Spray	10	5:00	Sparking	Moderate	Yes	No	3
13	40	Water	25:00	Stream/ Spray	15	5:00	Sparking	Substantial	Yes	No	2

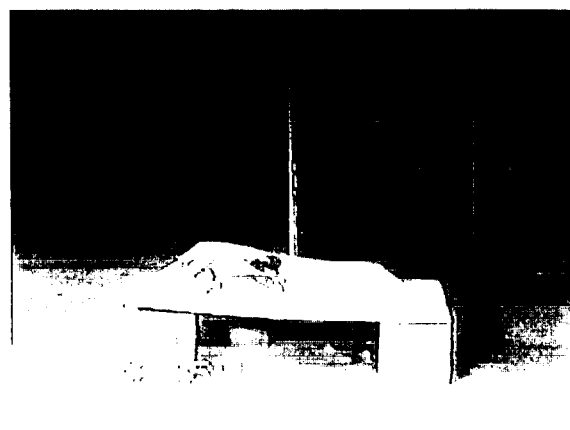
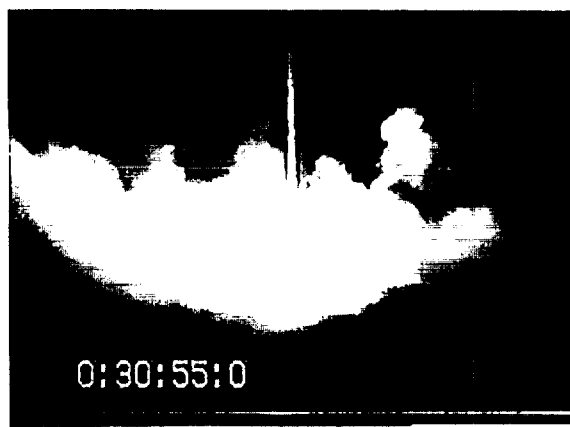
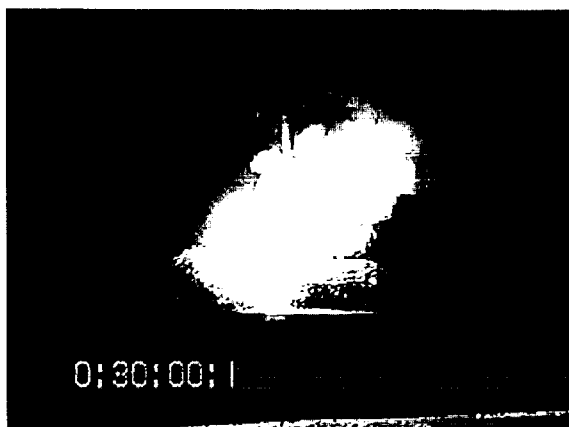
## Comments Description:

1. No flare-up or increase in burning intensity. Fire rapidly extinguished.
2. Substantial flare-up and sparking of burning magnesium even after burning fuel was displaced from test plate. Magnesium completely consumed.
3. Moderate flare-up and sparking of burning magnesium. Magnesium completely consumed.

NA - Not applicable

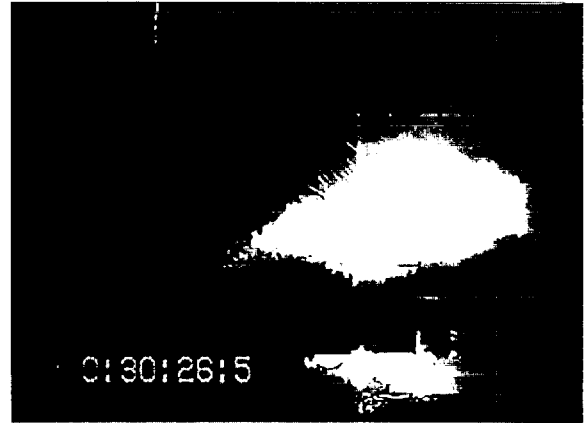
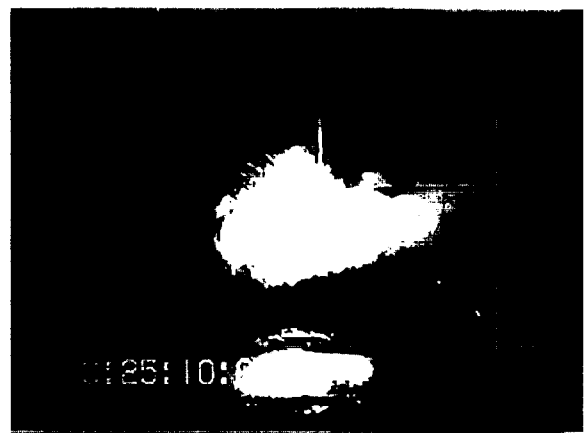


TEST NO.1

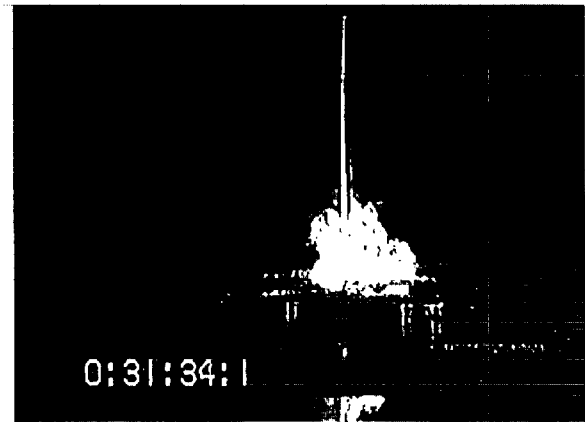


TEST NO.2

Figure 1. Magnesium chip fire tests, Class D dry powder

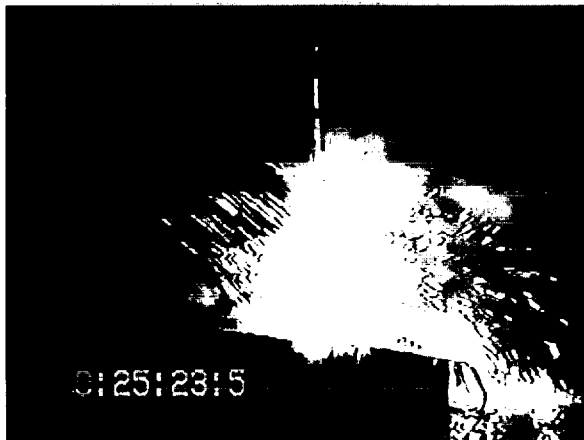
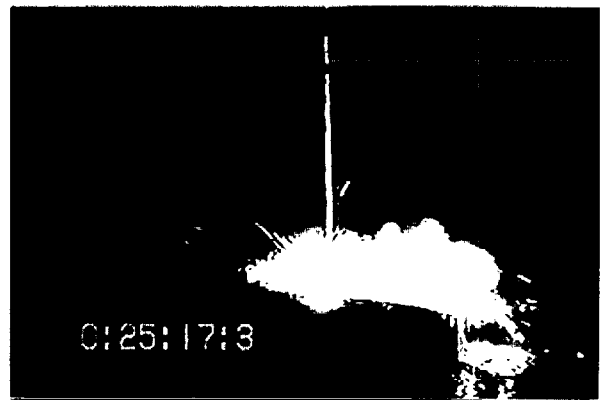
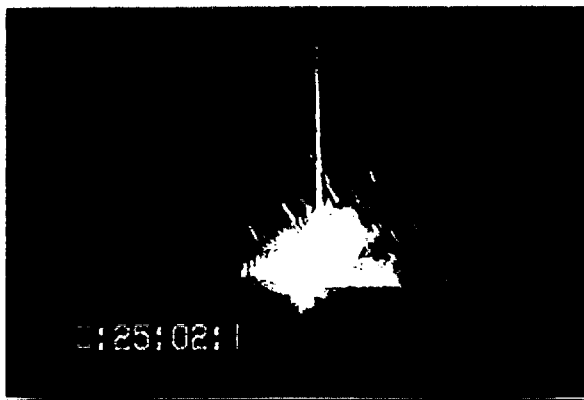


TEST NO.3

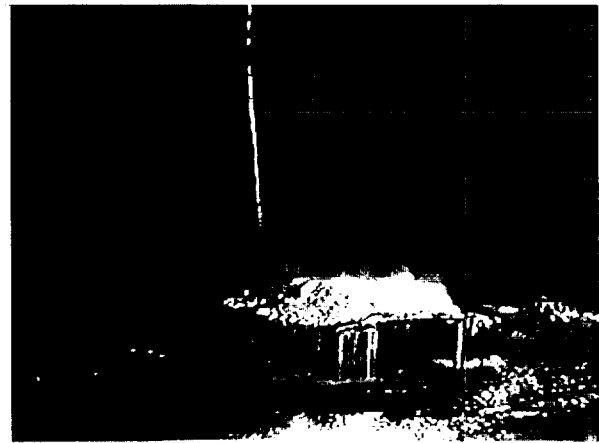
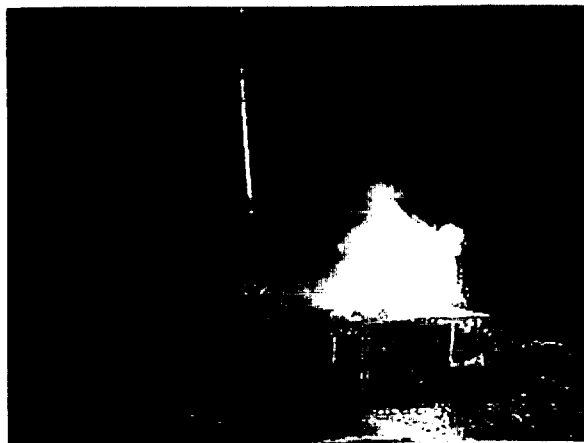
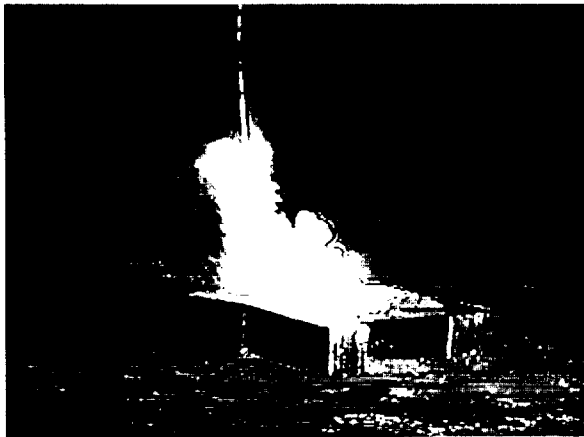


TEST NO.1

Figure 2. Magnesium chip fire tests, water only

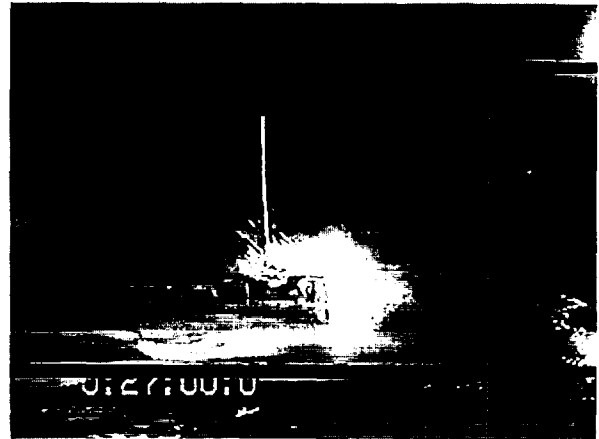
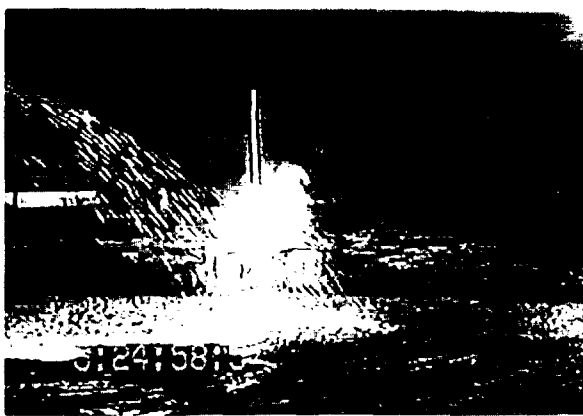


TEST NO.5

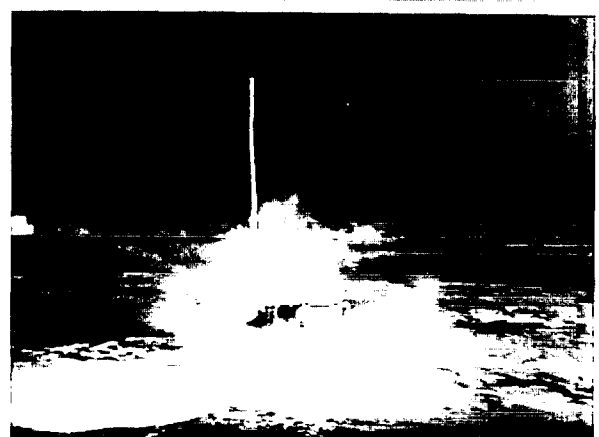
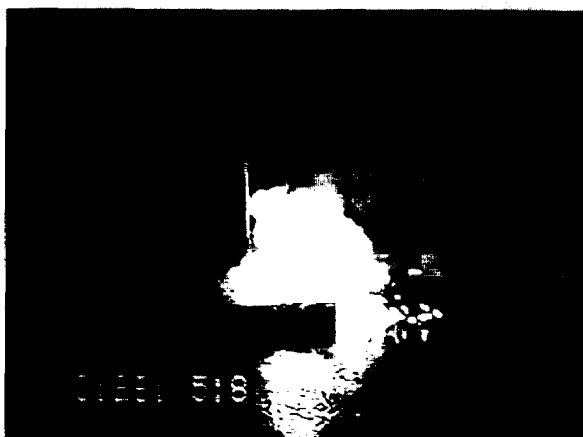
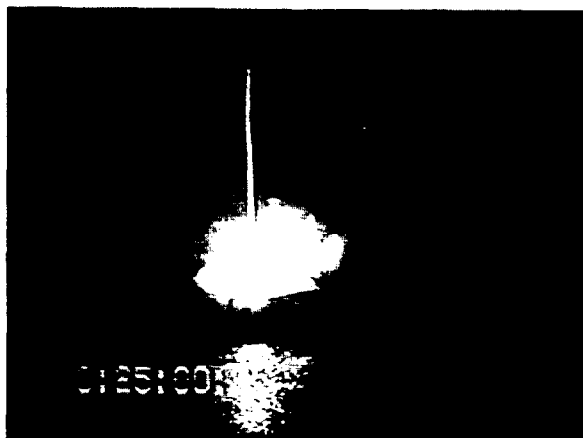


TEST NO.6

Figure 3. Magnesium chip fire tests, liquid agent A

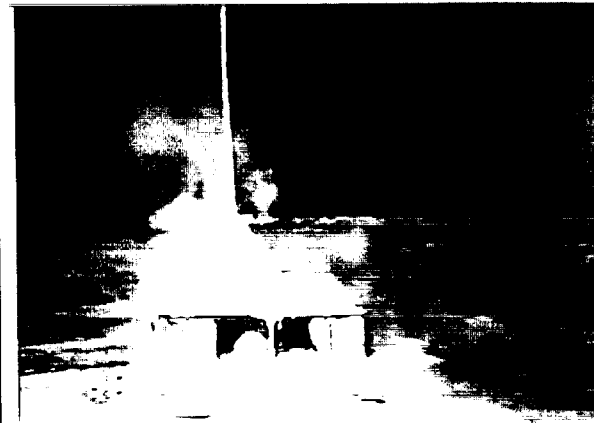
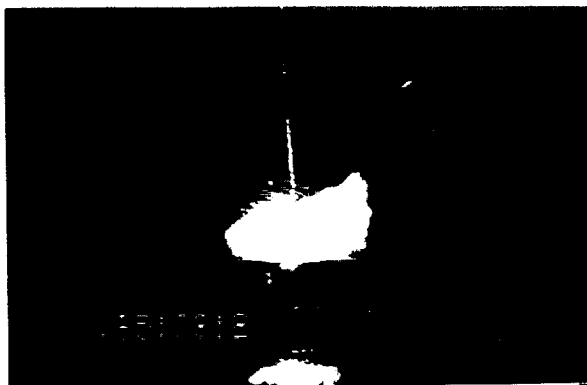


TEST NO.7

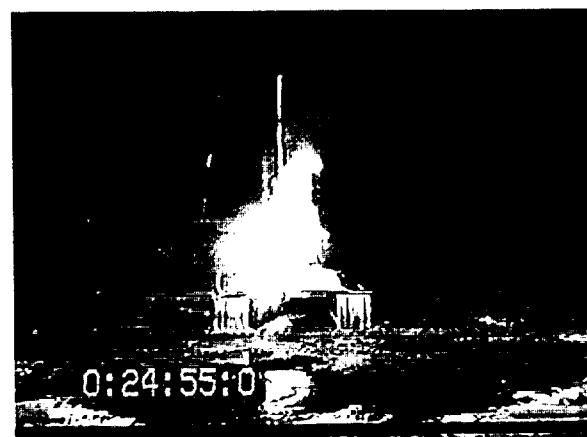


TEST NO.8

Figure 4. Magnesium chip fire tests, liquid agent B

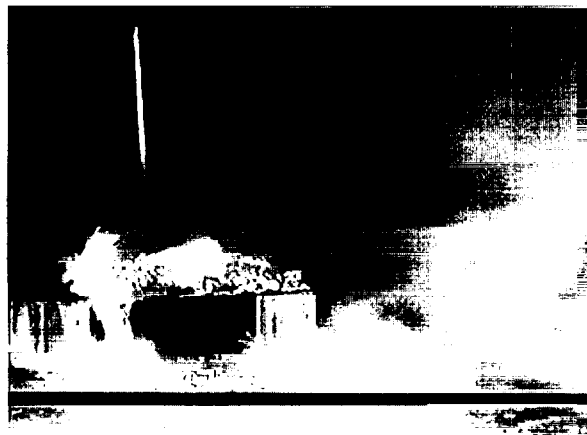
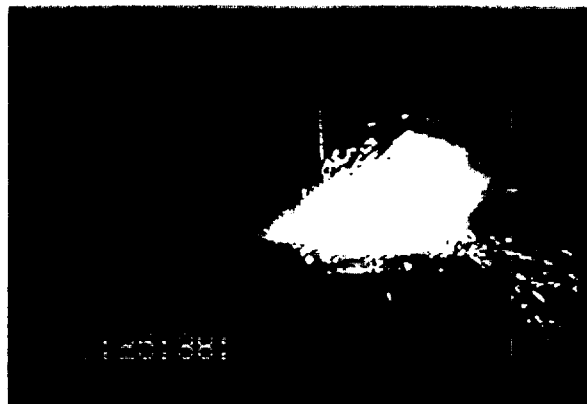
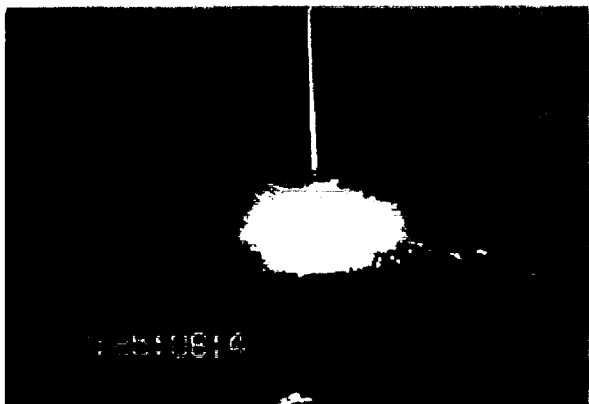


TEST NO.9



TEST NO.10

Figure 5. Magnesium chip fire tests, liquid agent C

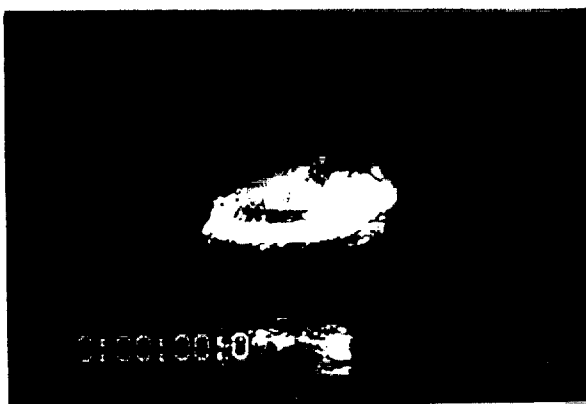


TEST NO.11

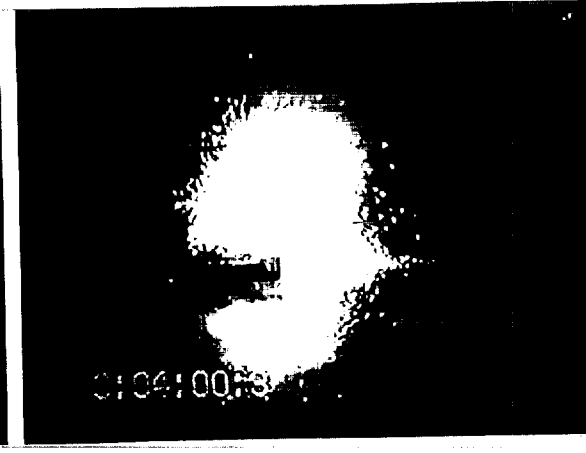
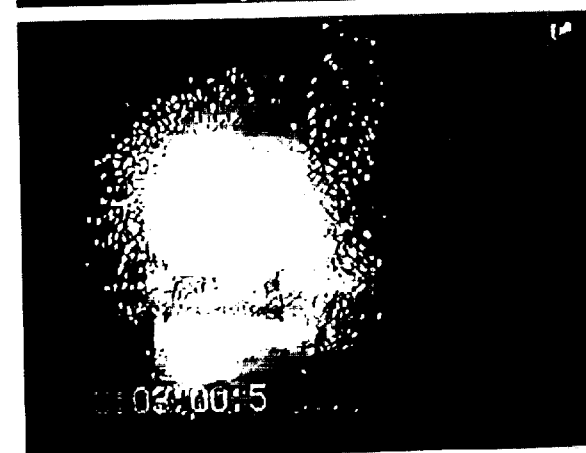


TEST NO.12

Figure 6. Magnesium chip fire tests, liquid agent D



TEST NO.13



TEST NO.13

Figure 7. Special magnesium chip fire test, water only



#### 4. 0 D I S C U S S I O N A N D R E C O M M E N D A T I O N S

##### DISCUSSION:

The results of the Class D, magnesium chip fire tests described herein indicate that the biodegradable, environmentally safe, nontoxic, liquid fire suppression agents were unable to extinguish a Class D combustible metal fire involving magnesium chips. The spray application method offered some advantage over the stream application method by providing a gentler application of agent onto the fire. This gentler application also resulted in smaller quantities of burning magnesium being scattered beyond the test bed area. When the magnesium material was scattered beyond the test bed area, it continued to burn intensely and had the potential to ignite other combustibles.

The tests conducted with the UL Listed Class D dry powder agent resulted in complete extinguishment of the test fires.

##### RECOMMENDATIONS:

Additional testing should be undertaken to further investigate the fire fighting performance of biodegradable, environmentally safe, nontoxic, liquid fire suppression agents, when applied to other common combustible metals.